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A User Manual for the Harpoon Shipboard Simulator

Jason McFarlane

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ABSTRACT

The Harpoon Weapons System (HWS) is the principal long-range anti-ship missile (ASM) in service with the ADF. Effective deployment of the missile is dependant upon operators being familiar with the sensitivity of the HWS to launch input parameters and environmental effects. The expense of live firings and the absence of appropriate range facilities in Australia severely restricts the opportunity for operator training. The use of a HWS simulator will be a valuable tool for operators to obtain familiarity with important aspects of the HWS. The Harpoon Shipboard Simulator is a Windows based missile simulator that allows a user to simulate missile firings using either manually entered data or data files down-loaded from the SWG1-A fire control system. Results of a missile simulation can be viewed as a simulation of the missile during flight time or as plots of the missile flight profile. Simulation launch settings and data can be saved to data files for later analysis and manipulation.

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Executive Summary

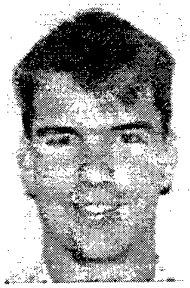
The Harpoon Weapons System (HWS) is the principal anti-ship missile (ASM) in service with the ADF, and is deployed on surface, sub-surface and air platforms. Harpoon is a complex weapon designed to operate autonomously over long ranges. For this reason the effectiveness of the HWS is particularly sensitive to the targeting data supplied at launch, and the effects of the environment during flight. Therefore, there is a need for operators and commanders to become familiar with the HWS to ensure they deploy the Harpoon missile to its maximum operational effectiveness.

The lack of an Australian range facility and the cost of live firing a Harpoon missile means that telemetry firings are not a practical option for operator training. A tool that enables operators to go through the same pre-launch processes and then obtain feedback on non firing exercise is valuable for the purposes of operator training, and post firing analysis of engagements for tactical considerations.

The Harpoon Shipboard Simulator package developed under task NAV93/294 provides operators with a windows based simulation tool that enables them to input firing data, either manually or via the SWG1-A fire control system, and obtain feedback of the outcome during non-firing exercises. Using the simulation package will enhance operator training value and give operators the ability to modify specific launch parameters and examine different firing outcomes.

This report is a user manual for the Harpoon Shipboard Simulator, and describes how to use the simulator program. The manual provides information on installation of the package onto a PC, how to set simulation data, either manually or by loading a settings file from the SWG1-A, running a simulation, and observing the outcome of a missile firing. The report also describes how data generated from a missile firing can be saved to disk, or printed to a printer for later analysis and re-runs.

Author



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Jason McFarlane is a Professional Officer in WSD. Since joining DSTO in late-1994 he has been involved in the modelling and simulation of radar guided missiles, and the development of graphical user interfaces for running simulations on a PC windows-based platform.

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1. Introduction

The Harpoon Shipboard Simulator (HSS) is a PC-based windows program that can be used to simulate Harpoon missile firings either on-board ship or ashore. The HSS can be used for operator training, pre-firing and post-firing analysis of Harpoon launches, and also for tactics development.

The HSS provides a graphical user interface (GUI) to a fly out model of the Harpoon missile. The GUI allows the input of data files extracted from the SWG-1A fire control suite on the FFG's, or manual input of data. The data includes missile parameters such as waypoints and seeker turn-on time and search mode, as well as environmental parameters and contact data. Detailed information about the extraction of data from the SWG-1A and the format of the reduced data files that are produced is contained in the manual listed as reference 1.

It is possible to specify up to six contacts, with the first specified contact as the primary target. It is also possible to include the position of known stand-off jammers or decoys as one of the contacts. The seeker search mode can be either range and bearing launch (RBL) large, medium or small, a bearings only launch (BOL) with the maximum range search (MRS) option, or a line-of-sight (LOS) mode.

The HSS uses this input data to simulate the expected outcome of the engagement specified. The simulated outcome is replayed graphically as a faster than real-time plot of the missile and contact trajectories. After seeker turn-on, the seeker search area is displayed on the plot and the seeker head pointing angle is displayed in a separate window.

A Cartesian axis plot of the missile and contact trajectories and the missile altitude profile can be viewed after the engagement has completed, as can a plot of the seeker head pointing angle. It is also possible to produce the plots in postscript format for later analysis. The simulation data generated can be saved in either binary or ASCII format.

Detailed technical information about the Harpoon model is contained in the working papers listed as reference 2 and reference 3.

2. Installation

The Harpoon Shipboard Simulator can be installed on your computer by executing the file *setup.exe* provided on the distribution disk. This executable file will extract and install all of the required files into the appropriate directories, and set up the program so that it is ready to be executed.

The Harpoon Shipboard Simulator cannot be set up by simply copying all of the files contained on the distribution disk onto your hard disk. The *setup.exe* file must be used.

2.1 Before Running *Setup.exe*

The Harpoon Shipboard Simulator has several hardware and software requirements which must be satisfied before the program can be installed and set up. The Simulator package should also be checked to ensure that everything is provided.

2.1.1 Check the System Requirements

The system requirements that must be satisfied include:

- Any IBM compatible machine with an 80386 processor or higher, preferably with a processor speed of at least 50 MHz .
- A hard disk.
- A 3 ½" disk drive.
- A SVGA or compatible display (minimum 800 × 640).
- One megabyte of memory.
- A mouse (a keyboard without mouse can be used).
- Microsoft MS-DOS version 3.1 or later.
- Windows version 3.0 or later in standard or enhanced mode.

2.1.2 Check the Harpoon Shipboard Simulator Package

The Simulator package includes the following:

- The Harpoon Shipboard Simulator User Manual.
- Program Disk.

2.1.3 Make Backup Copies of the Distribution Disk

Before running the installation program, backup copies of the distribution disk should be made. This can be done using the Copy or Copy Disk commands from the Windows File Manager, or by using the Copy or Diskcopy commands in MS-DOS.

2.2 Running *Setup.exe*

The installation program, *setup.exe*, will prompt you for a directory name in which to place the Harpoon Shipboard Simulator program. It will then extract the required files and copy them to the selected directory, as well copying other required files into the Windows system directory.

The installation program can be executed as follows:

I. Insert the distribution disk into the disk drive (A or B).
II. Either:
    A. Select Run from the File Manager File menu.
    B. Then type *a:setup* or *b:setup*.
    Or
    i) Double click on the file name *setup.exe* listed in File Manager.
III. Follow the instructions provided by the installation program.

3. Setting Simulation Data

After the Harpoon Simulator program has been successfully installed it is possible to execute the program and simulate missile firings.

3.1 Getting Started

The Harpoon Simulator Program can be started from either Windows or from the Windows File Manager.

3.1.1 Starting from the Windows File Manager

The Simulator program can be started as follows:

1. Select Run from the File Manager File menu.
2. Then type the directory name followed by *harpgui.exe*.
   Or
1. Double click on the file name *harpgui.exe* listed in File Manager.

3.1.2 Starting from Windows

To start the simulator program from Windows double click on the Harpoon Shipboard Simulator icon as shown in figure 3-1.

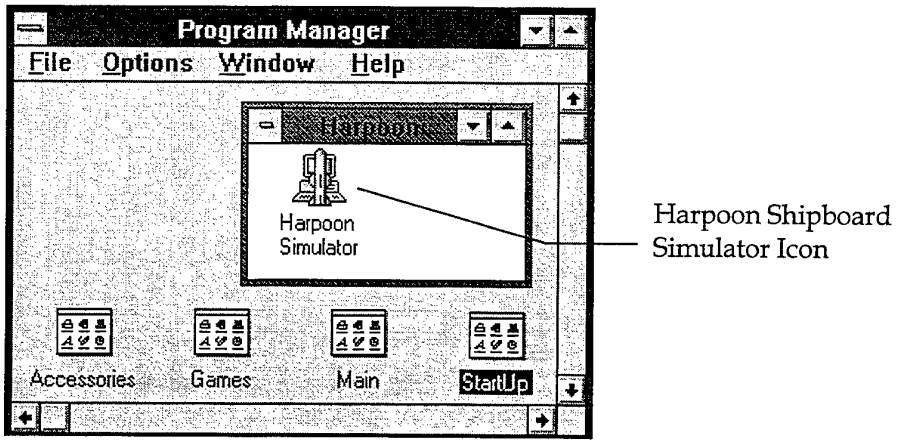

Figure 3-1 Program Icon in Windows

3.2 The Simulator Settings Window

The first screen to be displayed when the Harpoon Shipboard Simulator program is run is the main settings window shown in figure 3-2.

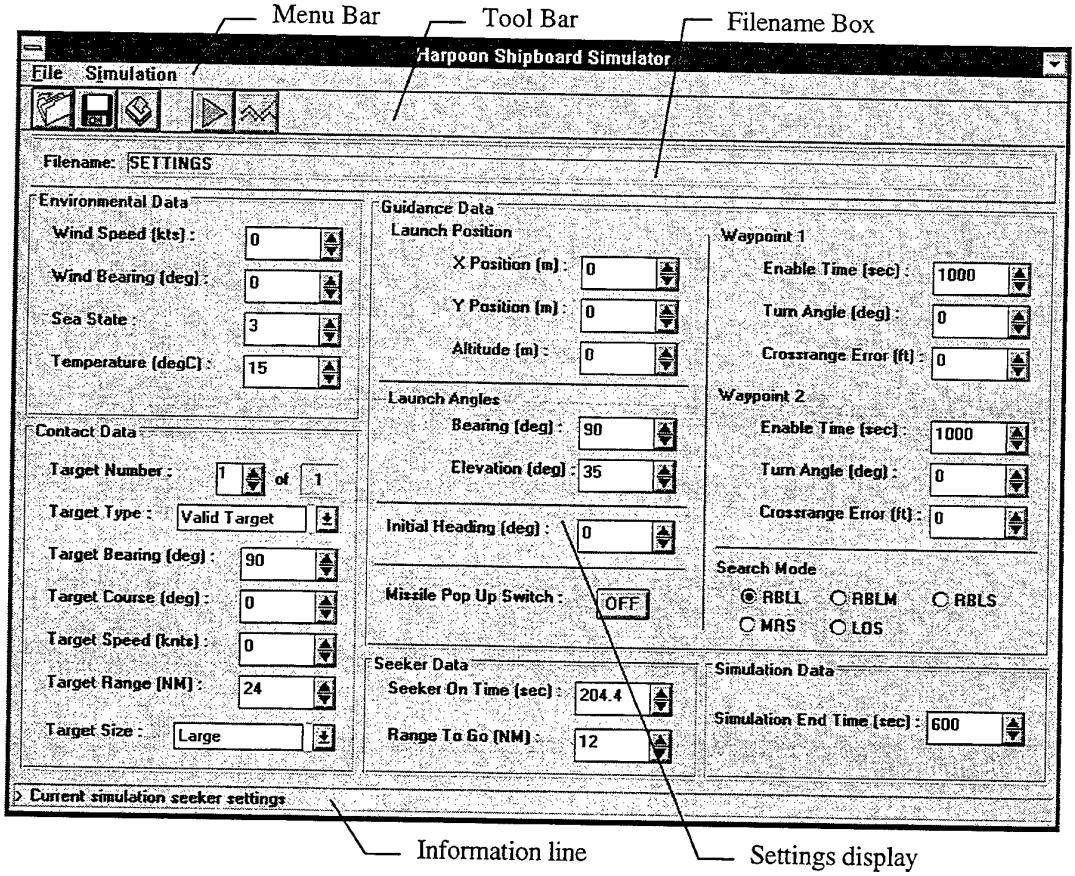

Figure 3-2 The Harpoon Shipboard Simulator Main Settings Window

The main settings window consists of a menu bar, a tool bar, a text box containing the current file name, the main settings display, and an information line.

3.2.1 The Menu Bar

The menu bar is used to access commands for controlling data input and output, running the simulation, and exiting the program. It contains a **File** menu, and a **Simulation** menu.

3.2.1.1 The File Menu

The File menu, figure 3-3, contains commands relating to input and output of simulation settings to and from the program. The quit command is also contained in this menu. The New command is also available and can be used to reset the simulator settings to their default values.

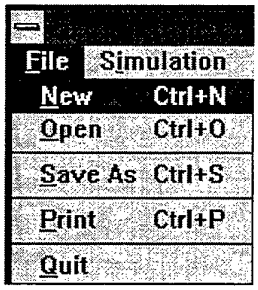

Figure 3-3 The File Menu

3.2.1.2 The Simulation Menu

The Simulation menu, figure 3-4, only contains two menu items and these are the commands for going directly to the simulator plot display window, without running a simulation, and the run command for running the simulation with the current simulation settings.

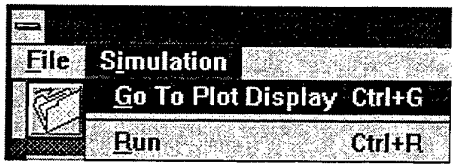

Figure 3-4 The Simulation Menu

Selecting the **Go To Plot Display** option will display the simulator plot display window, but without having loaded any simulation data. Before viewing a simulation

the simulation data from a previous firing must first be loaded using the **Load** option from the **File** menu, in the plot display window.

3.2.2 Settings Display

The settings display region of the main window shows the current simulation settings for the five sets of parameters, including environmental, target, guidance, seeker and simulation parameters. The display is updated when settings are modified, which can be done either by the use of the spin buttons attached to a parameters text box, or by entering new values directly into the text boxes provided.

Only one set of target data is displayed on the screen. To view other target data the spin button attached to the target number box can be used. Clicking on the up or down arrow of the spin button will increment or decrement the target number accordingly and all of the associated parameters for that particular target will be updated.

3.2.3 The Tool Bar

The following table shows the tool bar icons that are available for selection.

Table 3-1 Tool Bar Icons and Commands

Icon	Action	Menu equivalent
	Open a settings data file	**Open** command on the **File** menu
	Save current simulation settings to file	**Save As** command on the **File** menu
	Print the current simulation settings	**Print** command on the **File** menu
	Run simulation with current settings	**Run** command on the **Simulation** menu
	Go to plot display window	**Go to plot display window** command on the **Simulation** menu

The tool bar provides a set of icons for executing commands for data input and output, and running the simulation. The required action can be executed by clicking once on the corresponding icon, as described in the previous table.

3.2.4 Information Line

The information line is located at the bottom of the main display window and displays information relating to the current location of the mouse pointer. It describes what the tool bar icons are used for when the mouse pointer is located on a particular icon, it also describes what each of the menu items are for when one is highlighted.

Figure 3-5 Example of the Information Line when the Mouse Pointer is on the Run Simulation Icon

3.2.5 File Name Box

The file name box is located below the tool bar in the main settings window and displays the file name of the current simulation settings file. If there has not been a file opened or saved then the text box will display the name "SETTINGS".

The file name box cannot be edited and is for information purposes only. figure 3-6 shows an example of the file name box in its default state.

Figure 3-6 Example of the File Name Box

3.3 Loading a Data File

A settings data file can be opened by either selecting the **Open** command from the **File** menu or by clicking once on the Open file icon from the tool bar. Using either of these two methods will bring up an Open file window.

This window is similar to the Open file type of window used in other Windows applications. It allows the user to change working directories and then select the required file from the list of files displayed.

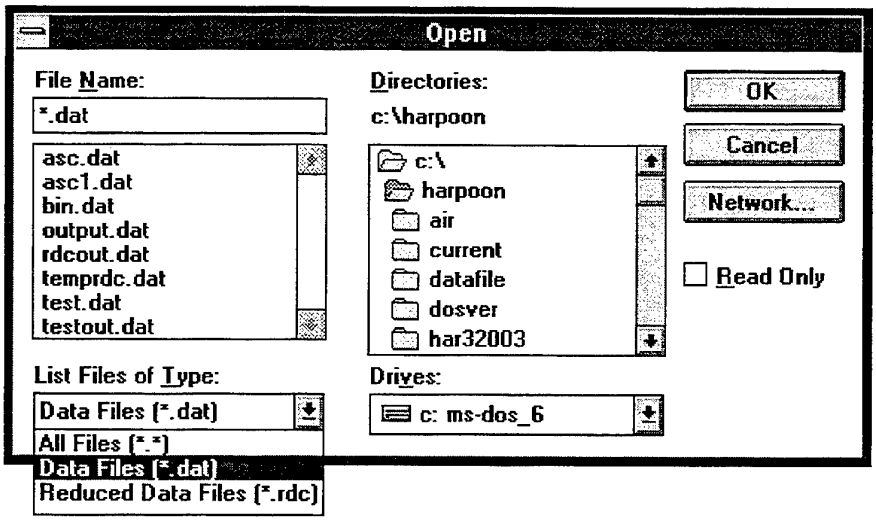

Figure 3-7 The Open Data File Window

There are two types of data files that can be used by the Harpoon Shipboard Simulator, these include *.dat* files and *.rdc* files. The *.dat* files are ASCII data files that have been generated by the Harpoon Shipboard Simulator program. The *.rdc* files are reduced data files that have been extracted from the SWG1-A fire control system. The specifications and format of both the *.rdc* and *.dat* files are contained in Appendix A.

When a new data file has been chosen and the **OK** button selected, the main settings window will become visible and it will be updated with the new simulation settings. Selecting the **Cancel** button will return control to the main settings window without changing any of the simulation parameters.

3.4 Modifying Simulation Settings

The simulation settings can be modified by either clicking on the up or down arrows of a spin button or by entering a new value directly into a parameters text box. The only settings that do not use the spin button method are the target type and the missile pop up switch.

3.4.1 Edit Box

The edit box can be used to enter new values directly without the use of a spin button. To enter data into an edit box click once within the border of the box and then use the keyboard to modify the existing value. Normal edit functions available on the keyboard, including the delete and backspace keys, can be used to modify values within the edit box.

3.4.2 Spin Button

A spin button is used to increment or decrement the value that is displayed in the attached text box. Clicking once on an up or down arrow will change the corresponding parameter by the smallest unit, nominally 1 for parameters that have a small change between simulations, such as temperature, and 5 for parameters that have a greater change, such as bearings.

Clicking on an arrow and keeping the mouse button depressed will continuously increment or decrement the corresponding parameter setting, until the mouse button is released.

3.4.3 Target Type List Box

The type of target for a particular target number is selected by the use of a list box containing the four possible target types, which include: valid target, no target, jammer, and decoy. Clicking on the arrow at the edge of the list box will display the list containing the different target types. Select one of these types by clicking the mouse button once on the required target type. Alternatively, the target type can be modified by clicking in the text part of the list box and then stepping through the possible target types by the use of the up and down cursor keys.

3.4.4 Missile Pop Up Switch

The missile pop up switch is a simple toggle button that is activated by clicking the mouse button once when the pointer is on top of the button. The text on the switch changes to indicate the current state of the switch. When the button is depressed it means that the missile pop up switch is on, and when the button is up the missile pop up switch is off.

3.5 Saving a Data File

A settings data file can be saved by either selecting the **Save As** command from the **File** menu or by clicking once on the Save file icon from the tool bar. Using either of these two methods will bring up the Save As Data File Window.

An example of the Save As Data File Window is shown in figure 3-8.

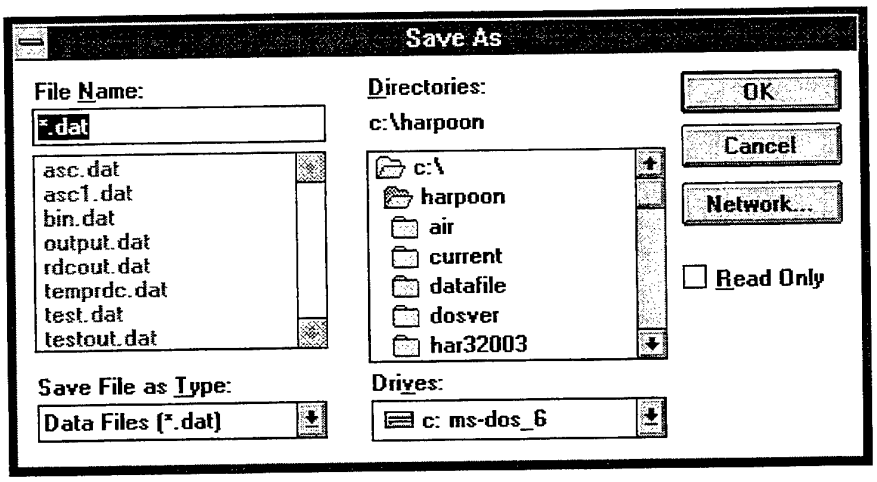

Figure 3-8 Save As Data File Window

Select the working directory in which to save the data file and then either select an already existing file name from the list or enter a new file name in the File Name edit box. The data files saved from the Harpoon Shipboard Simulator can be saved with the *.dat* file name extension or any other file name extension entered, except for the file name extension *.rdc*, because this refers to files in a specific format. The format of data files saved from the Main Settings Window is included in Appendix A.

After a file name has been entered click on the **OK** button to the save the current settings data under that file name, or click on **Cancel** to ignore the command and return to the Main Settings Window.

3.6 Printing a Data File

A settings data file can be printed by either selecting the **Print** command from the **File** menu or by clicking once on the Print file icon from the tool bar. Using either of these two methods will bring up the Print file Window.

An example of the Print file window is shown in figure 3-9.

The print window is similar to the print file prompts of other windows applications. Printing from the main settings window produces a single page print out of the current simulator settings on the selected printer. Changing the current printer is done simply by clicking on the **Setup** button and then following the prompts to choose a new printer, much like in other windows applications.

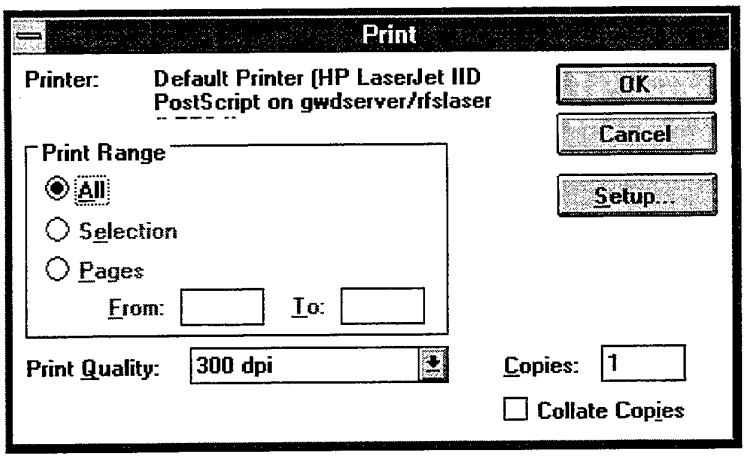

Figure 3-9 Print File Window

The only option available under the print range selection is the Print All option, because there is always only one page of data that will be printed, although multiple copies can still be printed.

3.7 Quitting the Harpoon Shipboard Simulator

The only method of quitting from the Harpoon Shipboard Simulator is to select the **Quit** command from the **File** menu. Selecting this command will cause a quit simulator window to be displayed, as shown in figure 3-10.

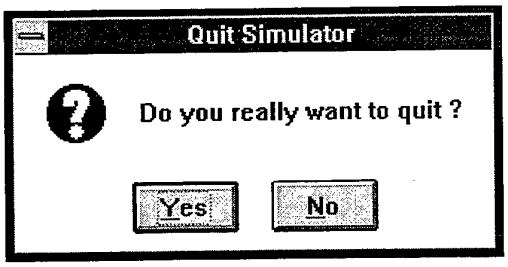

Figure 3-10 Quit Simulator Window

Clicking once on **Yes** will halt the execution of the program and return control to the normal Windows environment. Clicking on **No** will redisplay the main settings window ready for the modification of simulation settings or the running of a simulation.

4. Running a Simulation

After simulation settings have been entered or loaded from a data file the simulation is ready to be executed. The simulation can be run by clicking once on the run simulation icon in the tool bar or selecting the **Run** command from the **Simulation** menu.

Using either of these two methods will hide the main settings window and then display the generating data window shown in figure 4-1. This window will remain displayed whilst the program is generating simulation results and writing simulation data to an output file.

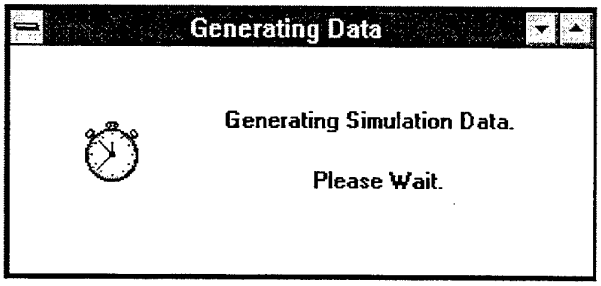

Figure 4-1 Generating Data Window

5. Examining Simulation Output

After data has been generated the Harpoon Plot Display Window will become enabled. This window consists of a plot display region, a menu bar, the seeker angle display, system information, and control buttons.

The Plot Display Window during a missile simulation is shown in figure 5-1.

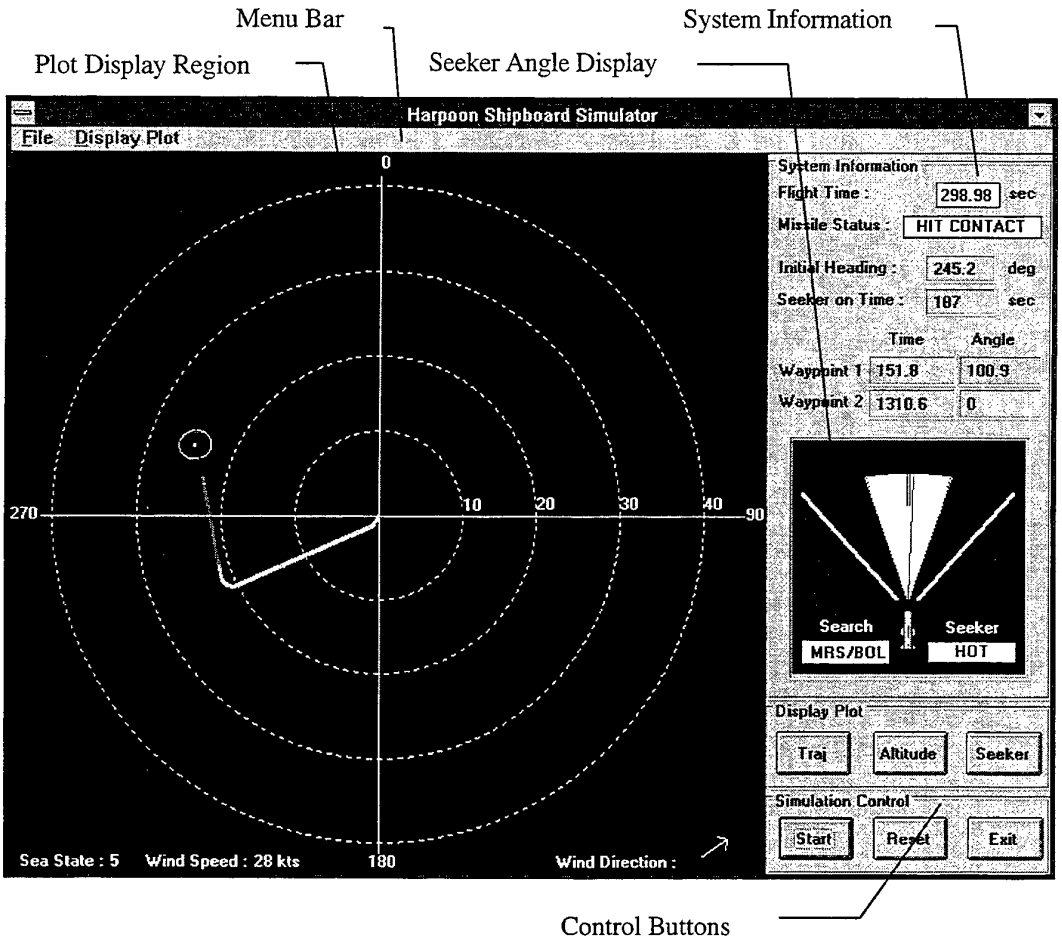

Figure 5-1 Harpoon Plot Display Window

5.1 Trajectory Display

The trajectory display shows the trajectory of both the missile and targets during the flight time of the missile. Other information contained on the display window includes the plot scale indicated on the x-axis in nautical miles, wind speed, sea state, and wind direction.

The missile trajectory is indicated by a multi-coloured line. A description of the color corresponding to each condition is contained in Table 5.1. The text "TGT" will flash in red next to target number one for the first 5 to 40 seconds to indicate the initial position of that target.

Table 5-1 Colour Combinations for Missile and Target Trajectories

Condition	Colour of Missile Trajectory	Colour of Contact
initial fly out	white	
initial search	cyan	
home on target (HOT)	light red	light red (target/s)
home on jammer (HOJ)	light green	light green (jammer/s)
home on decoy (HOD)	gray	gray (decoy/s)

5.2 Seeker Angle Display

The seeker angle display provides a graphical representation of the seeker head angle. The display becomes active once the seeker turn on time has elapsed. During the simulation run time the red line, the centreline extending from the head of the missile in figure 5-2, indicates the current position of the seeker angle whilst the white region of the display indicates where the seeker head has already scanned.

The search mode being used by the missile, and the status of the seeker at a given time are displayed in text boxes at the bottom part of the seeker angle display. An example of the seeker angle display after a simulation run is shown in figure 5-2.

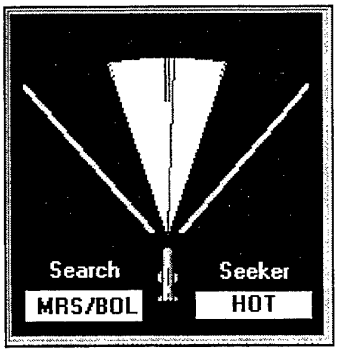

Figure 5-2 Seeker Angle Display

5.3 System Information

The system information contained on the Harpoon Plot Display Window includes the flight time of the missile, the status of the missile, the initial heading, the seeker turn on time, and waypoint information including start time and turn angle for each waypoint.

When the seeker power is on the seeker mode indicates the mode that the missile is in, which includes initial search mode (IS), home on target (HOT), home on jammer (HOJ), and home on decoy (HOD).

The flight time box displays the simulated flight time of the missile. The state of the missile describes the outcome of the missile firing, which can include hit contact, missed contact, passed contact, hit ground or aborted. The seeker turn on time and waypoint information are initialised when simulation data is loaded.

5.4 Control Buttons

The control buttons accessible from the Harpoon display window are for controlling the running of the simulation, displaying of plots, and exiting the simulation.

Figure 5-3 shows the control buttons that can be selected from the Harpoon Plot Display Window.

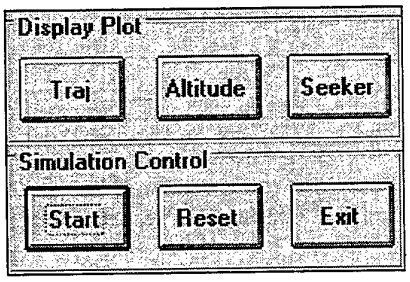

Figure 5-3 Control Buttons

5.4.1 Executing a Simulation

Running of the simulation is controlled by the simulation **Start** and **Reset** buttons. Clicking on the **Start** button after running a simulation from the settings window will start the plotting of the simulation data, otherwise a prompt window, figure 5.4, will be displayed indicating that simulation data must first be loaded before plotting can commence.

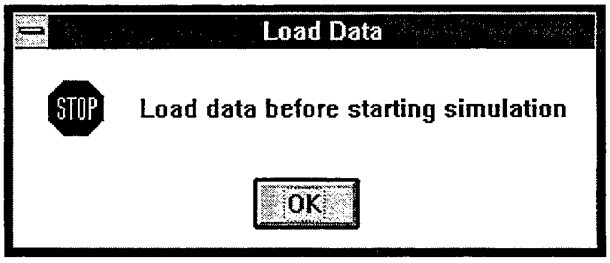

Figure 5-4 Load Data Warning Window

After the simulation has commenced and plotting of the missile and target trajectories has started the caption on the **Start** button will change to **Pause**. Clicking once on this button will pause the simulation. When the simulation is in a paused state the control button will have the caption **Resume**. Clicking on the button with the **Resume** caption will re-start the simulation at the time the simulation was paused.

The **Reset** button can be used to stop the simulation and reset the simulation parameters. When this command button is used the missile information display will show the state of the missile at launch time.

5.4.2 Plotting Missile Data

There are three types of plots that can be generated from a missile firing simulation. These include missile x-y trajectory plot (**Traj**), missile altitude plot (**Altitude**), and missile seeker head angle plot (**Seeker**). Clicking on any of the three plot control buttons will display the corresponding plot in the plot display region, replacing the trajectory display described in section 5.1. Examples of the types of plots that can be produced are included in Appendix B.

5.5 Menu Bar

The menu bar contains the **File** menu and **Display Plot** menu. The **File** menu is similar to the **File** menu in the main settings window and includes menu items for the input and output of data and exiting from the plot display window. The **Display Plot** menu contains a menu item for each of three plots that it is possible to generate. Selecting any of these options from this menu is the same as selecting the corresponding control button from the Display Plot control buttons, as described in section 5.4.

5.5.1 Saving and Loading Data

The menu items for loading and saving data are labelled **Load, Save** and **Save ASCII**. Selecting the **Load** option will display the load prompt window for selecting the file to load. The load prompt window is the same as the Open Data File Prompt window shown in figure 3-7 of section 3.3. The data files are binary files produced in a format specified by the Harpoon simulator program and described in Appendix A.

To display a previous simulation firing only binary data files can be used. These are the only type of files that can be loaded from the plot display window. The option of saving ASCII data files is provided to enable manipulation and viewing of simulation data using external packages.

The simulation information can be saved either as data, in a binary or ASCII data file, or as plots, in a word meta-file format or bitmap.

Selecting the **Save** item will display an option window from which the option of saving data or graphical output can be chosen.

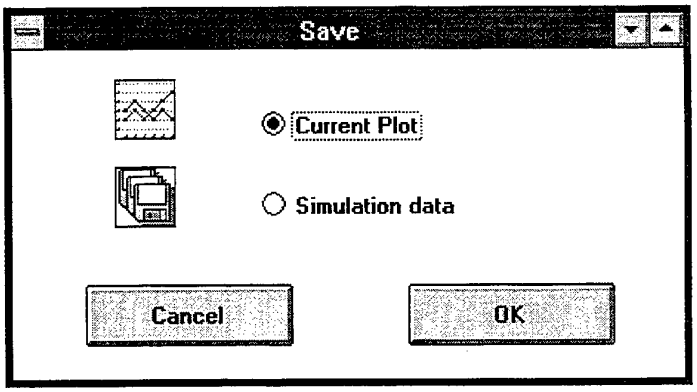

Figure 5-5 Save Option Window

Choosing either option and then clicking on **OK** will display the save prompt window which allows the file name to be entered and the directory in which to save the file to be selected. The save prompt window is the same window that is used for saving settings files from the Harpoon Main Settings Window shown as figure 3-8 in section 3.5. Data files are saved with the file extension *.dat*, whereas graphic plots are saved with either the *.bmp* file extension or *.wmf* file extension.

To save data in an ASCII format for viewing outside of the simulator program select the **Save ASCII** menu item. The save prompt window that is displayed is the same as the window used for saving graphical data and binary simulation data. The format of the ASCII data file is included in Appendix A.

Clicking on the **Cancel** button in any of the prompt windows will return control to the Harpoon Plot Display Window.

5.5.2 Exiting the Plot Window

To quit from the Harpoon display window select the **Exit** control button or select the **Exit** menu item from the **File** menu. A prompt window will be displayed with the option of quitting back to the main settings window, by selecting **Yes**, or cancelling the option and keeping the Harpoon plot display window enabled, by selecting **No**.

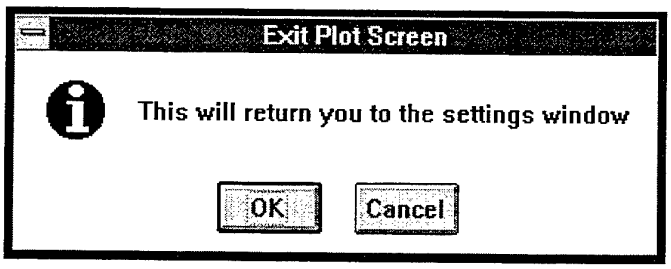

Figure 5-6 Exit Plot Screen Window

6. References

1. Royal Australian Navy, "AN/SWG-1A Data Extract and Reduction System Operator Manual", NSWSES 93043-5007, Version DRP-7.0A, March 1992. (Unclassified)

2. Coleman, C. S., "A Kinematic Model of the Harpoon Anti-ship Missile", Guided Weapons Division internal working paper, January 1993. (Secret)

3. Shipman, G. D., "A Description of the Harpoon Seeker Model", Electronic Warfare Division internal working paper, ECM Branch 94-04. September 1994. (Secret)

APPENDICES

Contents

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Appendix A: Input and Output Data Files

This appendix contains the file formats of the data files used for the input and output of data to and from the Harpoon Shipboard Simulator Program.

A-1 Format of SWG1-A Extracted Data File

The values indicated in bold are the values that are read when a *.rdc* file is selected from the open settings data file window. The values that are read in as **n/a** are assigned the value of zero and in the case of a target bearing and range being **n/a** the target is designated as target type *no target*.

```
HARPOON AN/SWG-1A DATA EXTRACT  ---  Reduced  6/08/1995

  Large Target      TARTAR RSR  1                          Data Block  8
                     Salvo Count = 1 of 1
 Trk = LOC 0001      Missile Type = RGM-84D
 Brg =  49.977 deg   Status Word = 00000 1 0000 111110          GMTR
 Rng =  64.736 kyd
 Hdg =   n/a   deg  Own-ship Hdg   =  56.375 deg   High-Alt Flyout: yes
 Spd =   n/a   kts   "   "   Pitch =   0.805 deg   Presearch Skim:  yes
 Sens = Active       "   "   Roll  =   1.758 deg   Terminal Mode: popup
 Data Age =  1 min   "   "   Speed =   5.453 kts
                                                   Search :  RBL
   Desig Aimpoint   Lchr Deck Brg  = 269.359 deg   Pattern:
                      "   "   Elev =  36.109 deg
 Brg =   n/a   deg                                 WP1 Brg =   n/a   deg
 Rng =   n/a   kyd  Launch Mode = STOT                 Rng =   n/a   kyd

  3rd Party / Bkgnd Launch Time = 00:21:35.96 Z    WP2 Brg =   n/a   deg
 Trk =   n/a        Flight Time =    03:58.63          Rng =   n/a   kyd
 Brg =   n/a   deg  Pwr-on Time =    00:21
 Rng =   n/a   kyd                                 WP3 Brg =   n/a   deg
 Sens =  n/a        Initial Turn =   84.367 deg        Rng =   n/a   kyd
                    Nav Error =   4.051 kyd       Tgt PACQ = .97
 Trk =   n/a
 Brg =   n/a   deg  Temp =  59.000 deg F           Precipitation = no
 Rng =   n/a   kyd
 Sens =  n/a        Wind =   0.000 deg /  0.000 kts
                                  Missile Orders
 Trk =   n/a
 Brg =   n/a   deg  CW-DW  OCT   HEX  CW-DW  OCT   HEX  CW-DW  OCT   HEX
 Rng =   n/a   kyd   4-0 000246 00A6   6-0 000243 00A3   A-0 000207 0087
                     4-1 007517 0F4F   6-1 000000 0000   A-1 000001 0001
 Trk =   n/a         4-2 043464 4734   6-2 045000 4A00   A-2 077777 7FFF
 Brg =   n/a   deg   4-3 015225 1A95   6-3 175063 FA33   A-3 000000 0000
 Rng =   n/a   kyd   4-4 000270 00B8   6-4 144012 C80A   A-4 000000 0000
                     4-5 020532 215A   6-5 004215 088D   A-5 077777 7FFF
 Trk =   n/a         4-6 024025 2815   6-6 000627 0197   A-6 000000 0000
 Brg =   n/a   deg   4-7 166154 EC6C   6-7 041104 4244   A-7 000000 0000
 Rng =   n/a   kyd   4-8 000000 0000   6-8 002260 04B0   A-8 000206 0086
                     4-9 000000 0000   6-9 032107 3447
 Trk =   n/a         4-A 124121 A851   6-A 111077 923F
 Brg =   n/a   deg
 Rng =   n/a   kyd   5-0 000165 0075   8-0 000244 00A4   B-0 000210 0088
                     5-1 145455 CB2D   8-1 000000 0000   B-1 000001 0001
 Trk =   n/a         5-2 155740 DBE0   8-2 000000 0000   B-2 077777 7FFF
 Brg =   n/a   deg   5-3 000032 001A   8-3 000000 0000   B-3 000000 0000
 Rng =   n/a   kyd   5-4 155740 DBE0   8-4 077777 7FFF   B-4 000000 0000
                     5-5 032322 34D2   8-5 000000 0000   B-5 077777 7FFF
 Trk =   n/a         5-6 177425 FF15   8-6 077777 7FFF   B-6 000000 0000
 Brg =   n/a   deg   5-7 133543 B763   8-7 000000 0000   B-7 000000 0000
 Rng =   n/a   kyd                     8-8 000000 0000   B-8 000207 0087
                                       8-9 035010 3A08
                                       8-A 035252 3AAA
```

The values shown in the missile orders section are in hexadecimal and correspond to the following parameters.

Reference Number	Conversion Factor (units)	Parameter
4-1	× 0.04 (sec)	seeker on time
4-2	× 4/6076 (nm)	range to go
4-3	× 0.04 (sec)	simulation end time
4-4	N/A	search mode
4-5	1 (nm)	xysearch (x value)
4-6	1 (nm)	xysearch (y value)
5-2	÷ 16384 (rad)	L21
5-5	÷ 16384 (rad)	L31
A-2	× 2 (time units)	1st waypoint turn time
A-3	÷ 4096 (radians)	1st waypoint azimuth command
A-4	× 4 (feet)	1st waypoint crossrange command
A-5	× 2 (time units)	2nd waypoint turn command
A-6	÷ 4096 (radians)	2nd waypoint azimuth command
A-7	× 4 (feet)	2nd waypoint crossrange command
8-4	(÷ 8192) × (180/Π) (degrees)	mid-course guidance command

A-2 Format of Settings data file

The settings data file is an ASCII file generated from the Harpoon Simulator program. This file is used to set the launch parameters for a missile firing and is given the file name *settings.in*, and is located in the application working directory, which is the directory selected when the program is installed.

```
HARPOON SIMULATION DATA

GUIDANCE DATA
"Launch Angles",325.5,34.3
"Initial Position",0,0,0
"Inititial Heading",54.6
"Waypoint 1",1310.6,0,0
"Waypoint 2",1310.6,0,0
"Pop up Switch",1
"Gyroscope Drift",0
"Search Mode",1

TARGET DATA
no_target = 0 Valid_target = 1 Jammer = 2 Decoy = 3
Target Type Range Bearing Course Speed Size
1,1,14.9,49.9,0,0,0
2,0,0,0,0,0,0
3,0,0,0,0,0,0
4,0,0,0,0,0,0
5,0,0,0,0,0,0
6,0,0,0,0,0,0
"Target Point Altitude",6

SEEKER DATA
"Seeker On Time",156.7
"Range to go",12

ENVIRONMENTAL DATA
"Wind Speed",0
"Wind Bearing",0
"Sea State",5
"Temperature",15

SIMULATION DATA
"Simulation End Time",272.1
```

A-3 Format of Simulation Data File

The table below describes the format of data that is output from the simulation program, and is the same as the data format used when the **Save** option is selected from the **File** menu of the plot display window. The data is stored as a binary data file. When a simulation is run from the main settings window the data file is given the file name *harp.out* and is located in the application working directory, otherwise the file name is selected from the save prompt window when the **Save** option is used.

Variable	Type	Number of Values	Description
num_time	int	1	number of time elements
num_seek	int	1	number of seeker data points
NUMVALS	int	1	number of simulation data points
sim_outcome	int	1	final outcome of simulation 0 : hit target 1 : hit ground 2 : missile past target 3 : missile outside firing envelope 4 : aborted
num_actions	int	1	number of missile actions during flight
msl_action	float	num_actions	flag indicating missile action 0 : home on target (HOT) 1 : home on jammer (HOJ) 2 : home on decoy (HOD)
msl_action_time	float	num_actions	time that action occurred
tsearch	float	1	seeker on time
windbrg	float	1	wind bearing
windspd	float	1	wind speed
seastate	float	1	sea state
trange(1)	float	1	range to target 1
wp1(1)	float	1	waypoint 1 activation time
wp1(2)	float	1	waypoint 1 turn angle
wp2(1)	float	1	waypoint 2 activation time
wp2(2)	float	1	waypoint 2 turn angle
num_tgts	int	1	number of targets
seek_on_time	float	1	actual time of seeker turn on (used for LOS/MRS)
search_mode	int	1	number indicating search mode used 1 : RBL large 2 : RBL medium 3 : RBL small 4 : MRS 5 : LOS
seeka	float	num_seek	seeker head angle values
xm	float	NUMVALS	missile x value
ym	float	NUMVALS	missile y value
zm	float	NUMVALS	missile altitude
xt1	float	NUMVALS	target 1 x value
yt1	float	NUMVALS	target 1 y value

Variable (cont)	Type (cont)	Number of Values (cont)	Description (cont)
xt2	float	NUMVALS	target 2 x value
yt2	float	NUMVALS	target 2 y value
trange(1)	float	1	target 1 range
tbearing(1)	float	1	target 1 bearing
trange(2)	float	1	target 2 range
tbearing(2)	float	1	target 2 bearing
trange(3)	float	1	target 3 range
tbearing(3)	float	1	target 3 bearing
trange(4)	float	1	target 4 range
tbearing(4)	float	1	target 4 bearing
trange(5)	float	1	target 5 range
tbearing(5)	float	1	target 5 bearing
trange(6)	float	1	target 6 range
tbearing(6)	float	1	target 6 bearing

A-4 Format of ASCII Data File

An ASCII data file can be created by selecting the **Save ASCII** command from the **File** menu in the plot display window. This type of file can be used to examine and manipulate simulation data externally to the Harpoon Shipboard Simulator program.

The data is written in columns with the following sequence: time in seconds, missile x, y, and z co-ordinates (xm, ym, zm), target one x and y co-ordinates (xt1, yt1), and target two x and y co-ordinates (xt2, yt2). All of the co-ordinate values are given in metres. An example segment of the data file produced is shown below.

```
0    -4.095773 -5.720469 4.543769 5893.728 31492.86 -10212.63 5248.583
.5   -4.095773 -5.720469 4.543769 5893.728 31492.86 -10212.63 5248.583
1    -22.96872 -20.07907 17.23276 5893.728 31492.86 -10212.63 5248.583
1.5  -57.94265 -43.69754 36.23877 5893.728 31492.86 -10212.63 5248.583
2    -109.7329 -76.98794 60.46595 5893.728 31492.86 -10212.63 5248.583
2.5  -179.0621 -120.3667 88.53826 5893.728 31492.86 -10212.63 5248.583
3    -266.3279 -174.0632 119.2089 5893.728 31492.86 -10212.63 5248.583
3.5  -360.4286 -231.6943 147.7099 5893.728 31492.86 -10212.63 5248.583
4    -454.9878 -289.5937 171.6457 5893.728 31492.86 -10212.63 5248.583
4.5  -550.2523 -347.903  191.0833 5893.728 31492.86 -10212.63 5248.583
5    -646.1482 -406.58   206.009  5893.728 31492.86 -10212.63 5248.583
5.5  -742.7062 -465.3879 216.4653 5893.728 31492.86 -10212.63 5248.583
6    -840.3992 -523.1498 222.7643 5893.728 31492.86 -10212.63 5248.583
6.5  -939.3243 -579.3885 225.0089 5893.728 31492.86 -10212.63 5248.583
                                        :
                                        :
120   -780.9865 18365.97 8.825041 5893.728 31492.86 -10212.63 5248.583
120.5 -720.3813 18489.24 8.693323 5893.728 31492.86 -10212.63 5248.583
121   -659.6819 18612.61 8.568035 5893.728 31492.86 -10212.63 5248.583
121.5 -598.8894 18736.02 8.448868 5893.728 31492.86 -10212.63 5248.583
122   -538.0049 18859.51 8.335511 5893.728 31492.86 -10212.63 5248.583
122.5 -477.0296 18983.08 8.227686 5893.728 31492.86 -10212.63 5248.583
123   -415.9649 19106.71 8.125122 5893.728 31492.86 -10212.63 5248.583
123.5 -354.8116 19230.41 8.027557 5893.728 31492.86 -10212.63 5248.583
124   -293.5713 19354.18 7.934756 5893.728 31492.86 -10212.63 5248.583
124.5 -232.2452 19478.01 7.846488 5893.728 31492.86 -10212.63 5248.583
125   -170.8341 19601.9  7.762536 5893.728 31492.86 -10212.63 5248.583
```

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Appendix B: Example Output Plots

This appendix includes an example of the three plots that can be produced from the Harpoon Shipboard Simulator program. They include a trajectory plot, missile altitude plot, and a seeker head angle plot.

B-1 Trajectory Plot

The trajectory plot is an x-y plot that displays the final trajectory of the missile and the first two targets, with the axes in metres. The x and y axis may not have the same scaling, hence plots may appear to be different to the simulated trajectory plot displayed in the main plotting window.

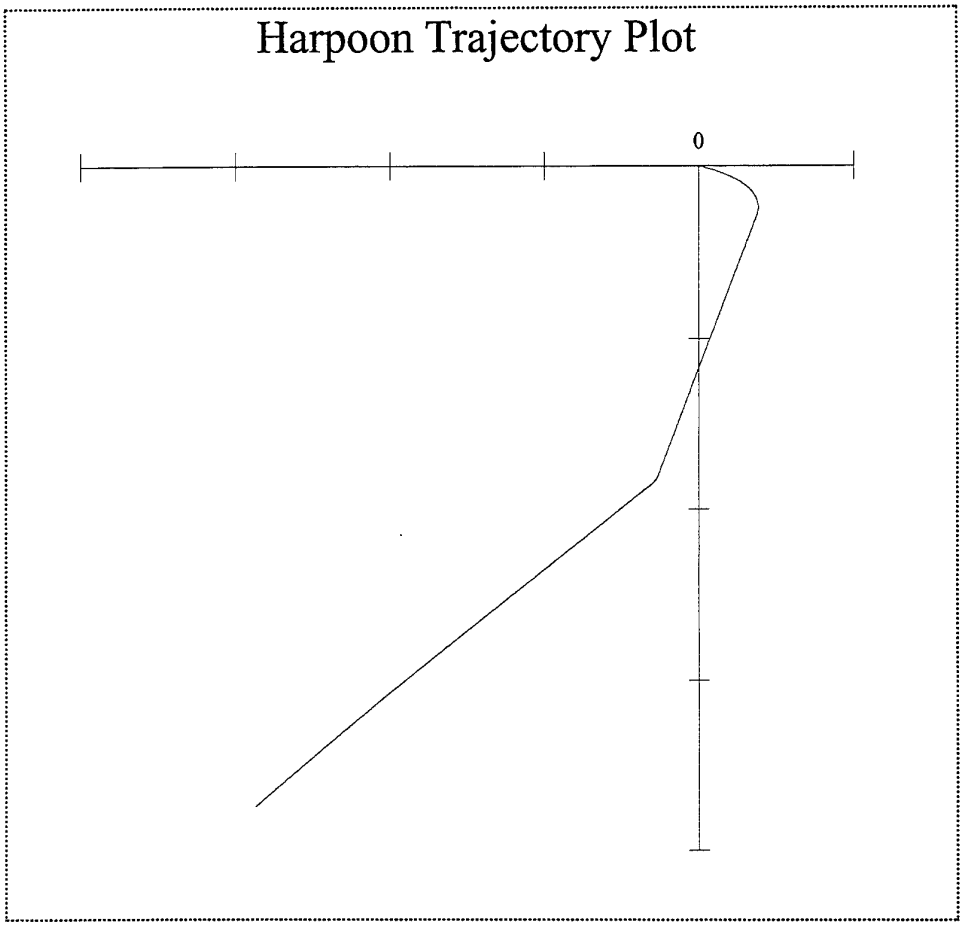

Figure B-1 Example of a Harpoon Missile Trajectory Plot

B-2 Altitude Plot

The altitude plot shows the altitude of the missile, in metres, over the duration of the simulated missile flight. Time is measured in seconds and is shown on the x-axis, scaled according to the total missile flight time.

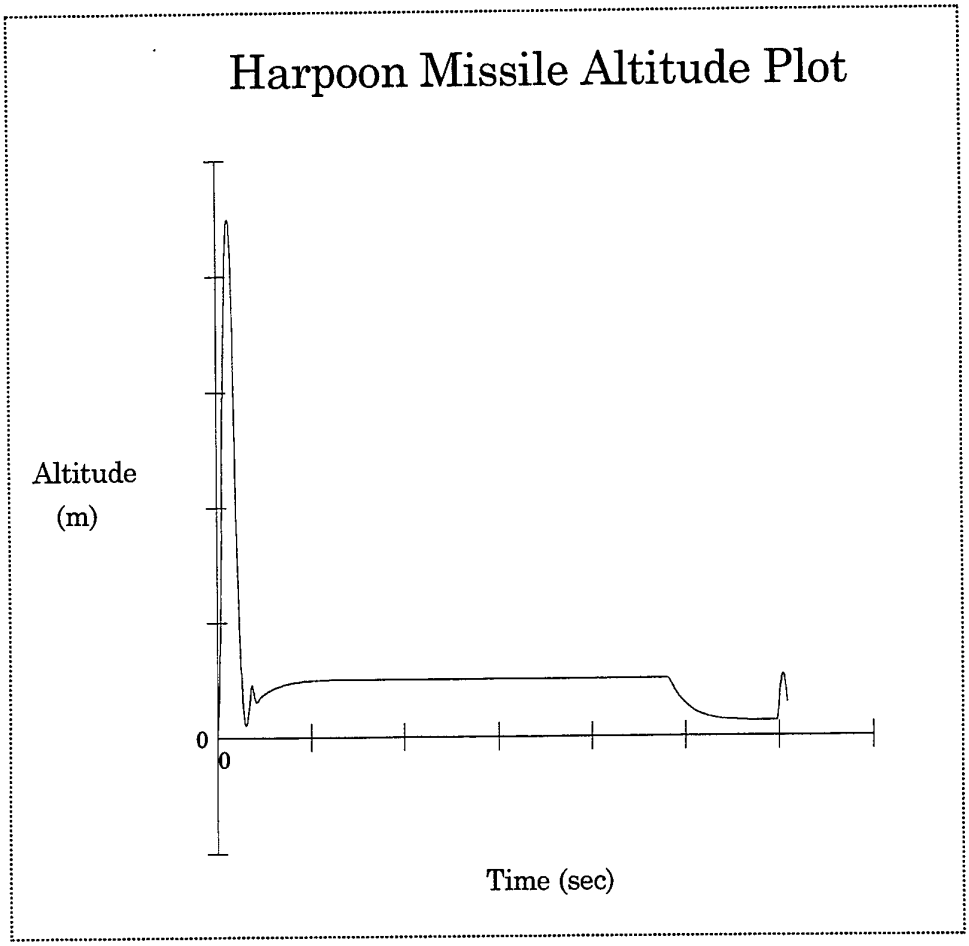

Figure B-2 Example of a Harpoon Missile Altitude Plot

B-3 Seeker Head Angle Plot

The seeker head angle plot shows the angle, in degrees, of the missile seeker head relative to the centreline of the missile. The seeker head angle is plotted from the time of seeker turn on until the end of the missile flight.

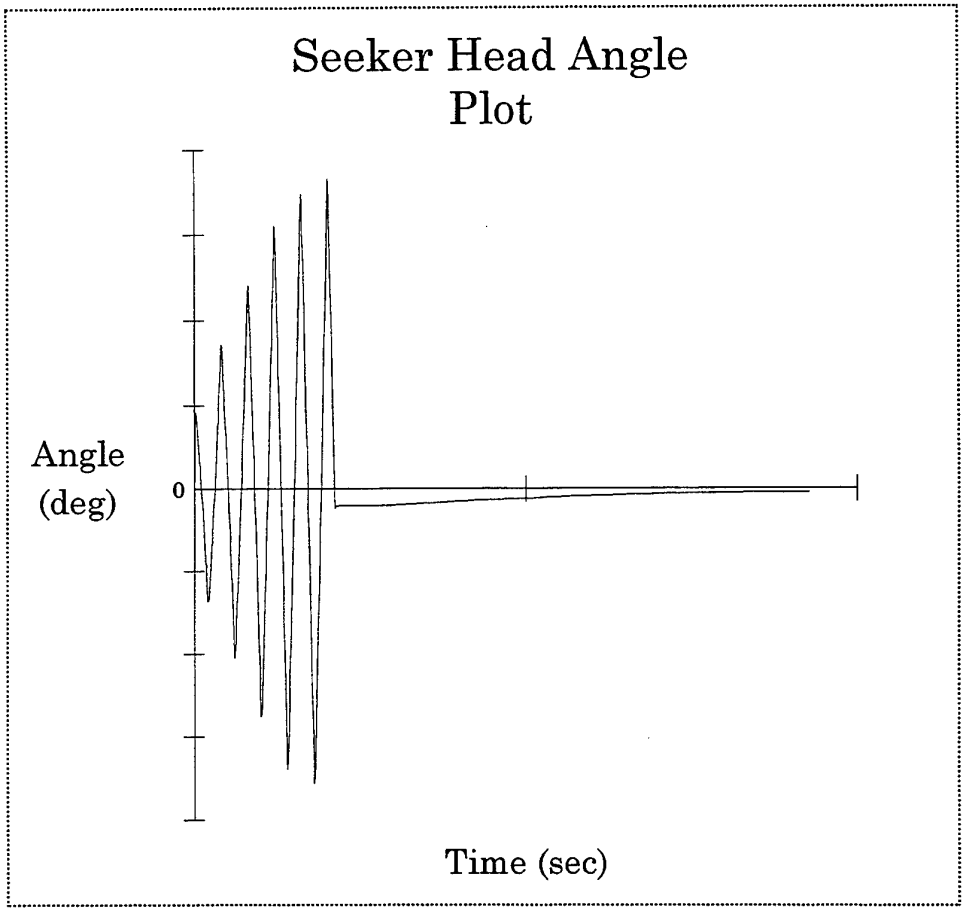

Figure B-3 Example of a Seeker Head Angle Plot

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Jason McFarlane

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19. ABSTRACT

The Harpoon Weapons System (HWS) is the principal long-range anti-ship missile (ASM) in service with the ADF. Effective deployment of the missile is dependant upon operators being familiar with the sensitivity of the HWS to launch input parameters and environmental effects. The expense of live firings and the absence of appropriate range facilities in Australia severely restricts the opportunity for operator training. The use of a HWS simulator will be a valuable tool for operators to obtain familiarity with important aspects of the HWS. The Harpoon Shipboard Simulator is a Windows based missile simulator that allows a user to simulate missile firings using either manually entered data or data files down-loaded from the SWG1-A fire control system. Results of a missile simulation can be viewed as a simulation of the missile during flight time or as plots of the missile flight profile. Simulation launch settings and data can be saved to data files for later analysis and manipulation.